[illegible] Nelson R.

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LAKE OF THE WOODS

TROPHIC STATUS
OF
SELECTED SITES

JUNE, 1977

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Ministry
of the
Environment

Ontario

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OF SELECTED SITES

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1.0 INTRODUCTION

Growing dependence of the Lake of the Woods Planning Area on tourism has created a need to ensure a buffer between the aesthetic value of the environment and the recreational demands of the public. It was in conjunction with this need that the Ministry of the Environment conducted a water quality assessment of Lake of the Woods during June, July, August and September, 1975. As a continuation of the program, ten more sites were examined during June, July and August, 1976.

2.0 SUMMARY AND CONCLUSIONS

There were no significant deviations from the trophic status established in the 1975 study (Varey, 1976). The variance exhibited between the 1975 and 1976 data for free ammonia, alkalinity, acidity and pH is insignificant.

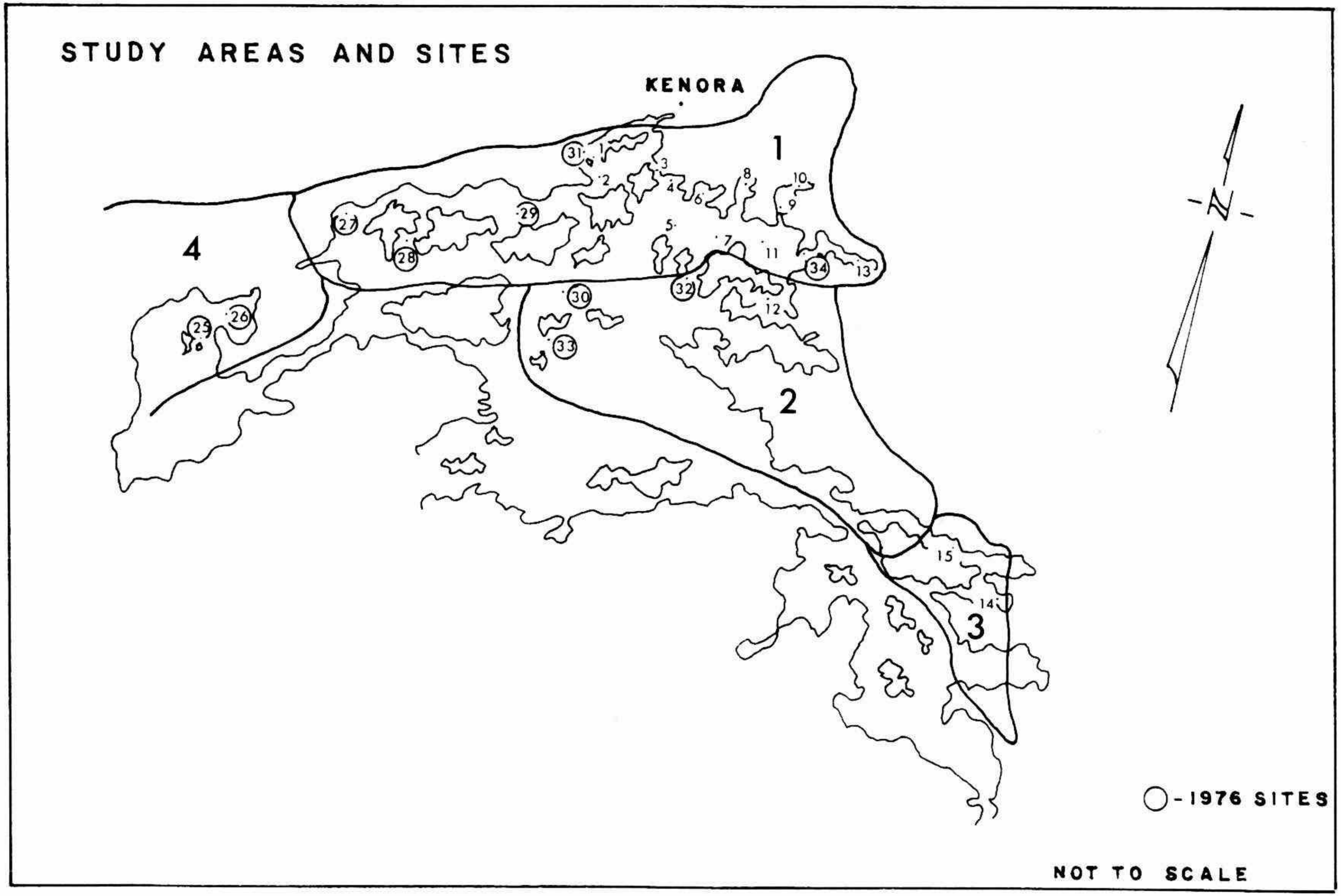
As "User Day" values and capacity models are being revised, the computations carried out in the first publication of the Lake of the Woods assessment (Varey, 1976) have been omitted.

3.0 SELECTION OF STUDY SITES

As for the previous study, the Ministry of Natural Resources submitted a number of priority areas related to impending development. The study sites were located to enable assessment of the water quality adjacent to these areas. Figure 3.0.1 exhibits both the 1975 and 1976 areas and sites.

Proposed development for the additional area (4) is as follows:

FIGURE 3.0.1


STUDY AREAS AND SITES
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○ - 1976 SITES
NOT TO SCALE

- cottaging
- public day-use facilities
- commercial tourist development on road-accessible patent land only
- resource extraction
- residential and commercial development on Reserve lands

4.0 METHODS

4.1 Physico - Chemical:

The sites were visited on five occasions with the exception of the site near Felix Island (25) which was sampled on four occasions. Two depths (one metre below the lake surface and one metre above the lake bottom) were sampled at each location and duplicate one-litre samples were collected at each depth. Samples were preserved (if required) and shipped to the Regional Laboratory for analysis for the following parameters:

Acidity
Alkalinity
Hydrogen ion Concentration (pH)
Total Phosphorus
Nitrogen Compounds
    (T.K.N., NH_3, NO_2, NO_3)
Sulphate
Hardness
Conductivity
Colour
Turbidity
Iron
Lead
Zinc
Nickel
Copper
Cobalt
Cadmium

To provide a sample for bacteriological analysis, one 150 ml sample was also collected at each site from one metre below the surface of the lake.

Oxygen and temperature regimes were determined directly in the field with a YSI model 57 oxygen - temperature meter.

5.0 RESULTS AND DISCUSSION

5.1 Water Chemistry:

The results of selected chemical analyses are provided in Tables I to VI of Appendix A. A summary of ranges in the concentrations of sampled parameters is provided in Table 5.1.1.

The results are consistent with those obtained in the previous study (Varey, 1976). Although there appears to be a difference in the two sets of data (1975-1976) with respect to free ammonia, acidity, alkalinity and pH, when put to a test of "one-way variance", the deviation was insignificant at the 95 percent confidence limit.

5.2 Bacteriology:

The bacteriological water quality of the study sites (Table VII, Appendix A) was acceptable by the Ministry of the Environment microbiological criteria for total body contact recreation:

> "Where ingestion is probable, recreational waters can be considered impaired when the coliform, faecal coliform and faecal

TABLE 5.1.1
A SUMMARY OF RANGES IN CONCENTRATIONS OF SAMPLED PARAMETERS

SITE NO.	25	26	27	28	29	30	31	32	33	34
Total Phosphorus	.018-.041	.014-.036	.010-.016	.012-.029	.014-.022	.017-.035	.013-.052	.013-.050	.018-.050	.014-.036
Total Kjeldahl Nitrogen	.42-.70	.42-.74	.21-.48	.32-.56	.35-.54	.35-.62	.36-.70	.34-.66	.36-.86	.33-.90
Ammonia	.01-.02	.01-.04	.01	.01-.04	.01	.01-.03	.01-.04	.01-.04	.01-.03	.01-.03
Nitrite	.001-.002	.001-.007	.001-.002	.001-.005	.001-.002	.002-.008	.001-.004	.002-.005	.002-.006	.002-.006
Nitrate	< .01	< .01	< .01	< .01	< .01	< .01-.04	< .01	< .01-.06	< .01-.02	< .0-.05
pH	6.8-8.4	6.7-8.6	6.4-8.1	6.6-8.1	6.9-8.3	6.8-8.1	7.2-8.0	6.4-7.9	7.1-8.0	6.9-8.1
Alkalinity	76-82	78-80	53-56	54-58	54-56	52-57	49-58	48-55	51-56	47-52
Acidity	.5-1	.5-2	.5-1	.5-4	.5-2	.5-1	.5-1	1-2	.5-2	.5-1
Hardness	76-80	72-82	52-62	54-60	54-60	50-58	48-55	50-60	48-64	46-53
Conductivity	148-156	146-155	111-115	116-120	112-115	109-113	109-112	109-112	109-115	99-108
Sulphate	2.0-3.5	2.0-4.0	3.0-5.0	3.0-4.5	3.0-4.5	3.0-11.0	2.0-4.0	3.0-5.0	3.0-5.0	1.0-6.5
Colour	< 5-5	< 5-15	< 5-15	< 5-15	< 5-15	15-20	15-30	15-30	15-20	10-20
Turbidity	1.6-2.5	.65-2.3	.65-1.0	.70-2.1	.80-1.7	1.3-2.3	1.1-4.3	1.1-4.3	1.6-4.8	1.0-4.7
Iron	.081-.150	.052-.064	.033-.035	.069-.081	.079-.086	.058-.078	.092-.210	.059-.110	.090-.093	.055-.110

SITE NO.	25	26	27	28	29	30	31	32	33	34
Lead	< .012	< .012	< .012	< .012	< .012	< .012	< .012	< .012	< .012	< .012
Zinc	.018-.032	.012-.014	.012-.013	.008-.012	.023-.033	.015-.016	.010-.015	.008-.011	.007-.083	.008-.009
Copper	< .004-.005	.007	.006-.007	.004-.016	.009	.004-.012	.005	< .004-.006	.004-.005	.005-.006
Nickel	< .004	< .004	< .004	< .004	< .004	< .004	< .004	< .004	< .004	< .004
Cobalt	< .007	< .007	< .007	< .007	< .007	< .007	< .007	< .007	< .007	< .007
Cadmium	.002-.003	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002	< .002

> streptococci geometric mean densities exceed 1000, 100 and 20 per 100 ml respectively". (M.O.E., 1974)

5.3 Secchi Disc - Chlorophyll a:

The mean summer values for chlorophyll a - Secchi disc monitoring are provided in Table 5.3.1.

Brown, 1972, indicated that a near-hyperbolic relationship exists between chlorophyll a concentrations and Secchi disc transparencies which can be used to "bracket" the trophic status of a lake. Figure 5.3.1 represents this relationship graphically and indicates that the study sites are within mesotrophic boundaries.

5.4 Temperature and Dissolved Oxygen:

The temperature and dissolved oxygen (D.O.) profiles for the study sites are depicted in Figure 5.4.1.

Based on mid-summer thermal distributions and dissolved oxygen concentrations, the study sites fall into two general categories:

(1) areas which lack a well defined thermocline and possess D.O. concentrations greater than 5 mg/l [5 - 6 mg/l are required to sustain cold water fish species, M.O.E., 1974];

TABLE 5.3.1: TRANSPARENCY - CHLOROPHYLL a RELATIONSHIP

SITE NO.	25	26	27	28	29	30	31	32	33	34
Mean Summer Secchi disc depth (m)	4.0	3.0	3.6	3.4	3.2	3.8	2.6	3.0	2.3	2.8
Mean Summer Chlorophyll a (ug/1)	16.4	8.5	3.0	4.5	3.9	3.2	5.0	4.2	5.2	5.3
Number of Samples	3	5	5	5	5	4	4	4	4	4

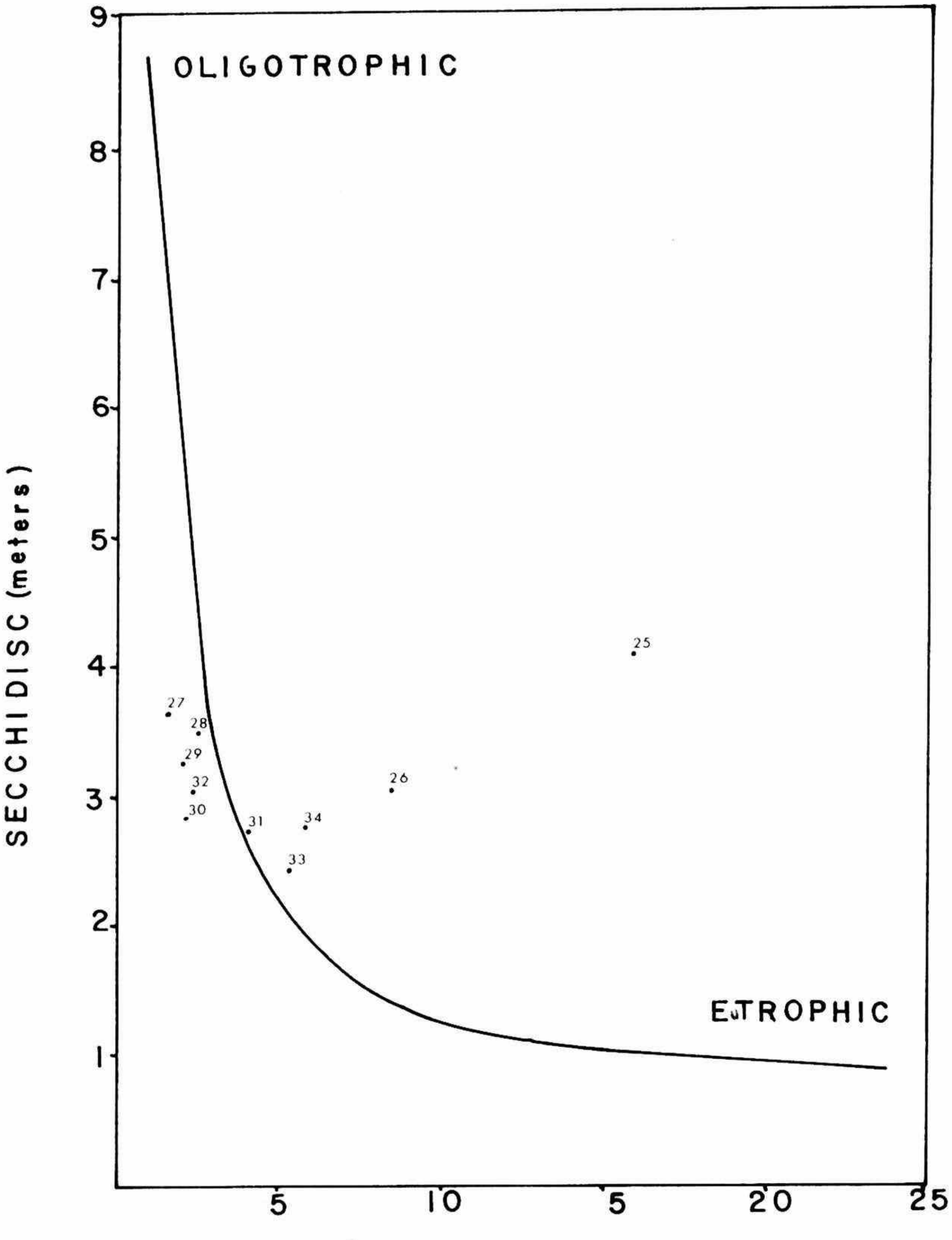
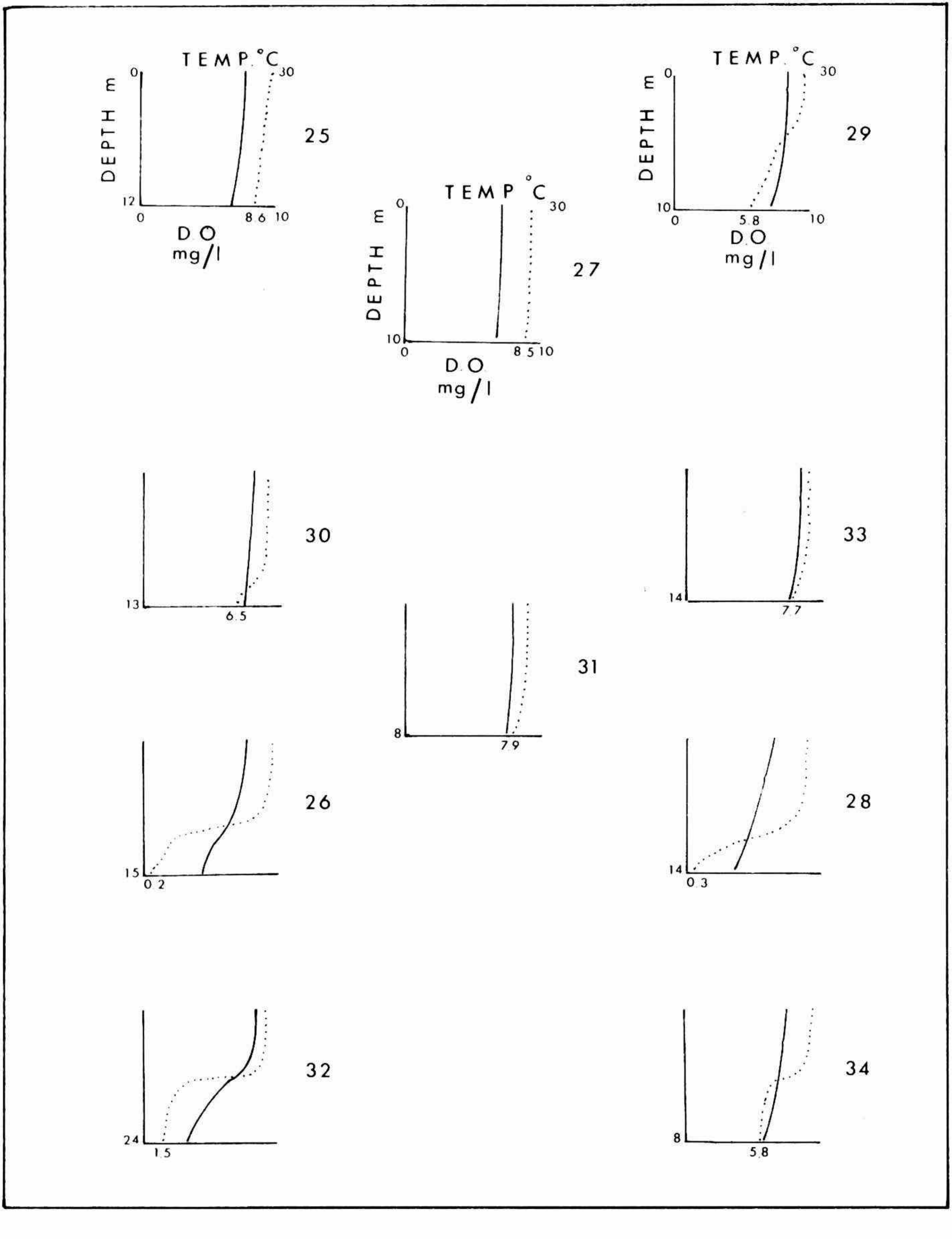


FIGURE 5.3.1

RELATIONSHIP BETWEEN CHLOROPHYLL a AND SECCHI DISC FOR THE STUDY SITES

FIGURE 5.4.1

MID SUMMER TEMPERATURE OXYGEN REGIMES



(2) areas which possess a well defined thermocline and/or exhibit hypolimnetic oxygen deficits, concentrations less than 5 mg/l.

Sites 25, 27, 29, 30, 31 and 33 exhibit the thorough mixing and dissolved oxygen concentrations of the first category. Aquatic environments with these characteristics are less susceptible to problems of eutrophication.

The remainder of the sites exhibit the bottom water oxygen deficits and corresponding clinograde oxygen distributions of the second category. These characteristics indicate substantial synthesis of nutrients into plant material and its subsequent decomposition at the expense of the oxygen resources in the hypolimnion. This reflects a vulnerability of these areas to artificial inputs of domestic wastes (Brydges, 1971).

5.5 Trophic Status:

Establishing the trophic state of a body of water is an attempt to relate it to a particular stage in the natural process (eutrophication) of the maturing of a lake. "The original state of all lakes must be assumed to be oligotrophic, but during the course of time there will always be a surplus of organic sediments accruing from the life process of a lake and the original oligotrophic lake is changed to a eutroph. The quantities of plankton, oxygen curves and average depths are the first features to be changed and the benthic community is last" (Welch, 1952).

With man's development of a lake, the addition of cultural inputs of nutrients increases the rate of the accruing process and aging of a body of water is speeded.

6.0 CONCLUSIONS

The results of the survey are consistent with the 1975 study (Varey, 1976). The trophic indices suggest that the study sites are of a mesotrophic nature. A lake at this stage of maturation is moderately productive and may be susceptible to cultural inputs of nutrients.

GLOSSARY OF TERMS

Clinograde - describes a type of vertical distribution where there is a decrease in oxygen levels with depth.

Euphotic Zone - the lighted region that extends vertically from the water's surface to the level at which photosynthesis fails to occur because of ineffective light penetration.

Eutrophic - describes a condition in which a lake is considered highly productive.

Hypolimnion - the bottom region of cool, homothermal water in a lake.

Mesotrophic - describes a condition in which a lake is considered moderately productive.

Oligotrophic - describes a condition in which a lake is unproductive.

Thermal Stratification - with the progression of the summer season the resistance to mixing between regions of different density (resulting from increased temperatures) become greater than mixing force due to winds. As a result, three density regions are established.

Trophic Status	depending on the degree of plant nutrient enrichment and resulting biological productivity, lakes are generally classified into three types: oligotrophic, mesotrophic and eutrophic.

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Limnology, second addition; McGraw-Hill, New York.

APPENDIX A

TABLE I: MEAN SUMMER PHOSPHORUS CONCENTRATIONS

SITE NO.	TOTAL PHOSPHORUS (mg/1)	
	Surface	Bottom
25	.028	.025
26	.022	.028
27	.013	.014
28	.018	.020
29	.018	.018
30	.023	.020
31	.018	.025
32	.021	.037
33	.029	.020
34	.025	.017

TABLE II: IRON (mg/1)

SITE NO.	SAMPLE	
	Surface	Bottom
25	.081	.150
26	.052	.064
27	.035	.033
28	.081	.069
29	.086	.079
30	.058	.078
31	.092	.210
32	.059	.110
33	.093	.090
34	.055	.110

TABLE III: MEAN SUMMER ALKALINITY-CONDUCTIVITY (T.D.S.)

SITE NO.	ALKALINITY AS $CaCO_3$ (mg/1)	CONDUCTIVITY $CaCO_3$ (mg/1)	T.D.S. (as calculated)
25	79	153 x .65	99
26	80	151 "	98
27	55	113 "	73
28	56	118 "	77
29	55	113 "	73
30	54	111 "	72
31	53	110 "	71
32	52	110 "	71
33	53	113 "	73
34	49	104 "	67

TABLE IV: RANGE FOR CONCENTRATIONS OF HARDNESS CALCIUM AND MAGNESIUM

SITE NO.	HARDNESS (mg/1)	Ca (as calculated)	Mg (as calculated)
25	76 - 80	24 - 26	16 - 15
26	72 - 82	23 - 26	15 - 17
27	52 - 62	17 - 19	9 - 14
28	54 - 60	17 - 19	11 - 12
29	54 - 60	17 - 19	11 - 12
30	50 - 58	16 - 18	10 - 13
31	48 - 55	15 - 18	10 - 10
32	50 - 60	16 - 19	10 - 12
33	48 - 64	15 - 20	10 - 14
34	46 - 53	15 - 17	8 - 10

TABLE V: HYDROGEN ION CONCENTRATION (pH)

	SITE NO.									
SAMPLE	25	26	27	28	29	30	31	32	33	34
Surface	7.6	8.0	7.7	7.9	7.9	8.1	8.0	7.9	8.0	8.0
Bottom	6.8	6.9	7.5	6.8	6.9	7.0	7.5	6.9	7.1	7.3
Surface		8.5	8.1	8.1	8.1	7.7	7.8	7.9	7.6	8.1
Bottom		6.9	7.6	7.1	8.1	6.9	7.7	6.8	7.1	7.0
Surface	8.4	8.6	7.7	8.1	8.3	7.3	7.6	7.4	7.5	8.1
Bottom	8.2	6.7	6.4	6.6	7.1	6.8	7.2	6.4	7.3	6.9
Surface	8.0	7.7	7.3	7.5	7.5	7.8	7.5	7.5	7.5	7.7
Bottom	8.1	8.0	7.3	7.5	7.6	7.6	7.4	7.3	7.5	7.4

TABLE VI: ACIDITY MEASURED IN $CaCO_3$ EQUIVALENT (mg/l)

	SITE NO.									
SAMPLE	25	26	27	28	29	30	31	32	33	34
Surface	1	0	1	1	1	.5	1	1	1	.5
Bottom	.5	1	.5	1	1	.5	1	1	.5	1
Surface		0	1	0	0	1	0	1	1	0
Bottom		1	0	1	0	1	1	1	2	1
Surface	0	0	0	0	0	1	.5	2	1	0
Bottom	0	2	0	4	2	1	1	2	1	1
Surface	.5	1	.5	.5	.5	1	1	1	1	1
Bottom	.5	.5	.5	.5	.5	1	1	1	1	1

TABLE VII: BACTERIOLOGICAL GEOMETRIC MEANS (per 100 ml)

SITE NO.	BACKGROUND	COLIFORMS	FAECAL COLIFORMS	FAECAL STREPTOCOCCI
25	2092	0	0	0
26	178	1	0	0
27	58	2	0	0
28	23	0	0	0
29	112	2	0	0
30	257	2	0	0
31	282	4	0	0
32	98	1	0	0
33	331	3	0	2
34	138	0	0	0

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